

SPECTRAL MEASUREMENTS OF METEORITE POWDERS: IMPLICATIONS FOR 433 EROS. T. H. Burbine¹, T. J. McCoy¹, E. Jarosewich¹, and J. M. Sunshine², ¹Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0119, USA (burbine.tom@nmnh.si.edu), ²Advanced Technology Applications Division, Science Applications International Corporation (SAIC), 4501 Daly Drive, Chantilly, VA 20151.

Introduction: One of the goals of the NEAR-Shoemaker mission to 433 Eros was to determine if it has a meteoritic analog. The primary means of making such a link are the X-ray/gamma-ray spectrometers [1], which measure elemental compositions of the surface, and the multi-spectral imager (MSI) and near-infrared spectrometer (NIS) [2], which measure spectral reflectance.

For determining meteoritic analogs using the X-ray/gamma-ray spectrometer data, the primary data used for comparison is the set of bulk chemical analyses of meteorites done by Jarosewich [3]. These bulk chemical analyses were done on samples now found in the Smithsonian's Analyzed Meteorite Powder collection (USNM 7073). For determining meteoritic analogs using MSI/NIS spectral data, the primary data used for comparison is the set of meteoritic spectra compiled by Gaffey [4].

To expand the set of meteoritic spectra available to the scientific community, we have initiated a spectral study of over 70 samples (primarily ordinary chondrites) found in the Smithsonian's Analyzed Meteorite Powder collection and an electron microprobe study of their corresponding thin sections. This set of spectral and compositional data should allow for better constraints on the distribution of meteorites in plots of band area ratios versus Band I centers [5] and the usefulness of equations for deriving mineralogic compositions from band parameters [6]. These spectral data can also be combined with previous spectral studies of other meteorite types such as the primitive achondrites [7], eucrites [8], and angrites [9] to determine how useful the derived band parameters are for differentiating between different meteorite classes. These spectral data can also be used for testing the Modified Gaussian Model (MGM) [10,11] for determining modal abundances and mafic mineral chemistries from reflectance spectra.

Meteoritic Powders: As part of the Smithsonian's meteorite research program, approximately 300 meteorites have been analyzed in the past 36 years for bulk chemical data [3]. The primary requirement for analysis was to obtain, if possible, sufficient amount material to assure a representative sample of the whole meteorite, and to retain some material for future studies. Usually from five to forty grams of a meteorite were powdered depending on the type of meteorite and the

mass available. These powders were prepared under clean conditions so that they can be used for trace element analyses and other types of chemical studies.

The meteorite samples were ground in an agate mortar in a hood with positive air pressure and then sieved through a nylon sieve to usually pass through 100 mesh ($< 150 \mu\text{m}$). A few samples were sieved to pass through 200 mesh ($< 75 \mu\text{m}$). This fine-powdered fraction ($< 150 \mu\text{m}$) consisted of silicates and sulfides and contained up to 0.4 wt.% of fine-grained metal. The meteoritic fraction larger than 100 mesh ($> 150 \mu\text{m}$) was primarily metal. A detailed description of the preparation of powders and the analytical procedures is given in Jarosewich [3]. Normative mineralogies for most of the ordinary chondrites, based on the bulk chemical analyses, are found in McSween et al. [12].

Reflectance spectra at room temperature were obtained on the powders using the bidirectional spectrometer at RELAB. The incident angle was 30 degrees and the emission angle was 0 degrees. The spectral coverage was 0.32 to 2.55 μm with a sampling interval of 0.01 μm . Almost all samples were also measured out to 26 μm using a Fourier transform infrared (FTIR) spectrometer. Selection of the powders for spectral analysis was done after visually examining each sample to check for possible weathering effects.

Results: Reflectance spectra and the olivine and pyroxene mineralogies for the ~70 meteorites are currently being compiled. To determine the Band I center, a linear continuum tangent to Band I is first divided out. We have now measured the band areas and band centers of 18 meteorite powders. We are currently estimating error bars for the calculated values. Their values are plotted on a Band Area Ratio plot (Figure 1) with the olivine, ordinary chondrite, and basaltic achondrite regions defined by Gaffey et al. [5]. The average band area and band center for 433 Eros determined by NEAR-Shoemaker [6] are also plotted.

An interesting preliminary result is that the new ordinary chondrite measurements fall in the lower range of the ordinary chondrite region defined by Gaffey et al. [5]. This offset is due to the calculated Band I centers tending to be at lower wavelengths than those calculated by Gaffey et al. [5] for similar types of ordinary chondrites. Measurements of all the ordinary chondrite powders should determine if this offset is real. It is important to determine the cause of this off-

set since 433 Eros does not yet plot in the region defined by the first measurements of these new ordinary chondrite powders.

One possibility for this offset is the almost complete removal of metallic iron from the measured powders. Moroz and Arnold [13] have found that addition of opaques (e.g., pyrrhotite) to an olivine-orthopyroxene mixture tends to move the Band I center to longer wavelengths. We are currently planning on re-mixing the metallic iron with the fine-powdered fraction to determine if the Band I center changes with the addition of metallic iron.

Another possibility is that the wavelength calibration correction of 0.025 μm that is used [14,15] on the Gaffey [4] meteorite data is too large. This correction is done because of a later-discovered wavelength offset found between the spectra taken by the spectrometer that measured the Gaffey [4] meteorites and more recent spectra. By comparing spectra of an Apollo soil sample taken by the Gaffey [4] spectrometer and the RELAB spectrometer, Pieters and Pratt [16] found that a non-linear wavelength correction, which has an offset of +0.015 μm at a wavelength of 0.92 μm , was better. We are planning on measuring a number of ordinary chondrites also measured by Gaffey [4] to determine which wavelength calibration is better.

Of the meteorites measured, two of the most interesting mineralogically are the ungrouped chondrite Burnwell [17] and the R-chondrite Rumuruti [18]. Burnwell is more reduced than H chondrites with olivine compositions of $\text{Fa}_{15.8 \pm 0.2}$ and pyroxene compositions of $\text{Fs}_{13.4 \pm 0.7}$. Burnwell plots amongst the H chondrites in the Band Area Ratio plot (Figure 1). Rumuruti is an oxidized ($\sim\text{Fa}_{39}$), olivine-rich, metal-poor chondrite. As expected, Rumuruti plots within the olivine region (Figure 1).

A preliminary fit (Figure 2) using MGM was also done on LL6 chondrite Bandong. The model requires olivine and two pyroxenes (a low-calcium and a high-calcium). Inferred modal abundances derived from this model are within 10% of those derived from normative calculations. These results are consistent with those of McFadden et al. [6] where both low- and high-Ca pyroxenes are needed to produce the Band I centers consistent with those of ordinary chondrites.

Conclusions: We are re-examining the regions defined by different meteorite classes in Band Area Ratio plots. These data will allow us to better determine the compositions of asteroids from remote sensing.

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Acknowledgments: Brown University's Keck/NASA Reflectance Experiment Laboratory (RELAB) is a multi-user facility supported by NASA grant NAG5-3871.

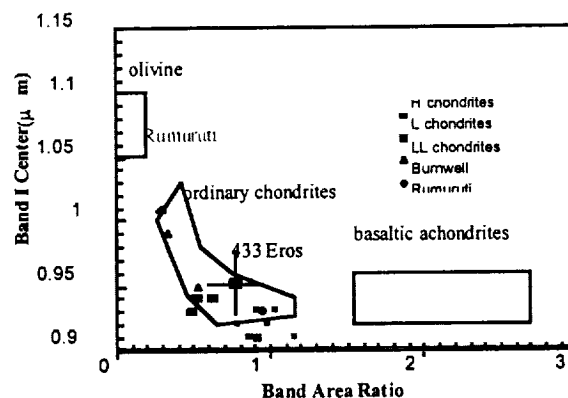


Figure 1. Plot of Band Area Ratios versus Band I Centers.

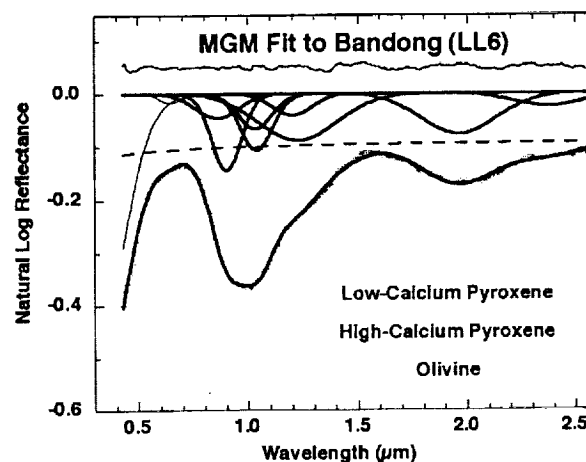


Figure 2. MGM fit to LL6 chondrite Bandong.